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MECHANICAL AND THERMAL CHARACTERIZATION OF CHICKEN RACHES/SAWDUST REINFORCED HDPE HYBRID COMPOSITES

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ABSTRACT

This project emphasized on the wastage, which can be recycled and gives a better product which can stop spoiling the environment. In our country, there are so many different types of waste products, which will come from different categories like factories, forms and houses. Among them two fibers such as neem saw dust, chicken feather rachis and HDPE granules are chosen. These materials are combined to prepare granules by using single screw extruder and strand pelletizer machines. So that 7 compositions with different ratios are prepared using those granules. They are 80H-10CF-10SD, 80H-5CF-15SD, 80H-15CF-5SD, 80H: 20CF, 70H: 30CF, 70H: 30SDand 80H: 20SD. For those samples, Mechanical Properties using MFI and Specific Gravity tests, thermal properties using TGA and DSC tests and Optical properties using FTIR testing's for all samples will be determined. The above ratio samples are having better mechanical, thermal and optical characteristics when compared to individual fibre materials.

KEYWORDS: Chicken Riches, Saw Dust, HDPE Granules, Reinforced Material & Mechanical and Thermal Properties

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Original Article

1. INTRODUCTION

Today, people are educated more towards environmental impacts and issues against the products, which are effecting than ever before. Government policies are compelling companies and industries to find alternative resources to substitute the non-renewable ones. This has moved us towards natural resources and their utilization. However, while the need for environment friendly applications is rising, the concern about the scarcity and accessibility of natural resources is raised. At the same time, development in urbanization, the raise in population and better living standards create huge amount of waste time to time. This waste consists of bio-based products [1, 2] which could be recycled. The industries and researchers are paying attention on modern methods to use bio-based waste materials in order to provide value added non-conventional and sustainable product solutions to replace non-renewable ones.

When observing the globally abundant, inexpensive waste streams and unique, which could be utilized for value Added applications, one cannot pass poultry industry. The waste from poultry industry comprises of feathers, residual meat, internal organs, skin, feet blood and bones. From these By-products, especially, feathers have renowned interest. It has been expected that in 2017, only the broiler meat generation maybe 89.5 million tons worldwide according to USDA, 2017. The poultry waste may be around 30 % of its total weight according to Harikumar, 2005 and chicken feathers fiber constitute around 10 % of chicken's weight according to Grazziotin, 2007, the chicken feather fiber[3,4] waste can be expected to be 12 million tons, worldwide.

Supri A Gani et al [5] reinforced the low density polyethylene with chicken feather rachies. This composition is made with Z-blade mixer. There is mainly two types of compositions are made such as LDPE and Chicken Feather Fibre (CFF) and LDPE, CFF and PEgMAH. Tensile test was performed on the composites, and youngs module of each composition is calculated from the test. Mass swell test is performed to find the swelling properties of the composite material. The spectra were identified by perkin elmer spectrum. The TGA analysis of LDPE and CFF composites with or without PEgMAH was done with Elmer 6 TGA analyzer. It was concluded that combination of LDPE, CFF and PEgMAH is giving better tensile strength, thermal stability, youngs module and having low mass swell.

Masoudreza Habibi et al [6]compounded plastic waste coming from MSW, LDPE and HDPE. The mechanical and rhelogical properties of composite material were observed. The recycled materials mixed in two ways such as simultaneous mixing of all compounds and premixing of compounds. The MFI test was performed to study the melt viscosity of composite material and is an indicator of the modification in molecular weight. It was found that the recycling improves the viscosity of the composite matrial. Flectural and tensile tests shows that the premixing improves the mechanical properties of composite material compared to simultaneous mixing. The rhelogical tests prove that the premixing material will have the better complex viscosity and storage modules.

Isiaka oluwole oladele et al [7] combined the chicken feather fibre with HDPE granules. The composite materials obtained from the natural fibres from plants have limitation of absorption of high moisture content, so natural fibers from the trees are replaced with chicken feather fiber. Spectrophometer is used to calculate morphology and crystallinity index. XRD and SEM analysis is performed on the different ratios of composite material such as 2,4,6,8, and 10% fiber ratio with HDPE granules. ASTM D3038M-08 and ASTM D7264M-07 standards are used to perform tensile and flexural tests. It was finally observed that reinforced material is having better mechanical and thermal properties when compared to the non- reinforced HDPE material.

Abdul Ghani Supri et al[8]compounded the chicken feather fiber, HDPE and ε-caprolactum. Tensile test, mass swell test, sem analysis and TGA tests were carried out with and without ε-caprolactum. The tests are performed with different loadings of CFF and ε-caprolactum. It was concluded that the combination of HDPE, CFF and ε-caprolactum provides better tensile strength, FDT and modulus of velocity. In this paper, the two fibers such as neem saw dust, chicken feather rachis and HDPE granules are chosen. Mechanical and thermal properties are obtained using various tests.

2. MATERIALS

In this project, we used chicken feather rachis and saw dust (neem tree bark) as fibre and HDPE granules as matrix.

2.1 Chicken Feather Rachis

The chicken feathers[9,10] obtained from farm were washed at 40°C with washing matter, which has a dirt and grease remover specialities, and sodium hypochlorite(NACIO) in terms of not damaging the fibers. After the water of feathers was taken in the centrifuge, the feathers were dried at a temperature of 40°C in a laboratory-type feather dry machine at Erciyes University Department of Textile Engineering and disinfection was applied for 12 minutes at 70°C temperature. The dried feathers were subjected to the process of separation from the rachis part of the barbs part. Separated fibers and barbs were collected separately. The fiber collected from the Rachis is as shown in Figure 2.

2.1.1 Structure of Chicken Feather

The structure of Chicken Feather is as shown in figure 1

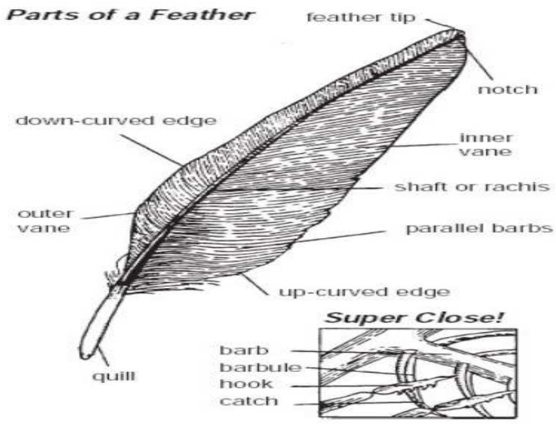

Figure 1: Structure of Chicken Feather.

Figure 2: Separated Fiber Material from Chicken Feather.

2.2 Neem Saw Dust Process

In this paper, neem tree bark [11, 12] dust is used which is collected from near mill. The tree bark is passed through the cutter machine so that the powdered form is coming out in the form of smooth dust, which is collected in bag and used for this work. Neem saw dust is as shown in Figure 3.

Figure 3: Collected Neem Saw Dust.

2.3 HDPE Granules

HD50MA180 is a high flow High Density Polyethylene (HDPE)[13] grade. This grade is specially formulated to manufacture large, intricate, thin walled multi cavity injection moulded products. It has narrow molecular weight distribution, which makes it easier to process and products manufactured have good gloss and rigidity. The HDPE Granules are as given in Figure 4.

Figure 4: HDPE Granules.

2.4 Process of Granules

In this paper, I have used two fibers and one matrix, fibers are chicken feather rachis and neem saw dust, matrix is HDPE granules with these materials, I have made granules with different compositions. They are mentioned below.

80H-10CF-10SD,80H-5CF-15SD, 80H-15CF-5SD, 80H: 20CF, 70H: 30CF, 70H: 30SD, 80H: 20SD.

3. TESTINGS

The following are the different testing methods which ensure the quality of the composite material developed.

- **Thermal Analysis**
  - Thermo Gravimetric Analysis (TGA)
  - Differential Scanning Calorimetry (DSC)
- **Optical Properties Spectroscopy Techniques**
  - Fourier Transform Infrared Spectroscopy (FTIR)
- **Metal Flow Index (MFI)**
- **Specific Gravity (SG)**

3.1 Thermo Gravimetric Analysis (TGA)

Thermo Gravimetric Analysis or **Thermal Gravimetric Analysis** (**TGA**) is a method of thermal analysis, in which we can measure the mass for the sample over time as changes with temperature. This physical phenomena provides the information about the measurement such as phase transitions desorption's and absorption; as well as it includes chemisorption, thermal decomposition and solid-gas reactions in chemical phenomena. In this process, the weight loss at different percentage for the temperatures can be shown. So that it will give how much weight loss is done at different temperature ranges. Block diagram is as given in Figure 5.

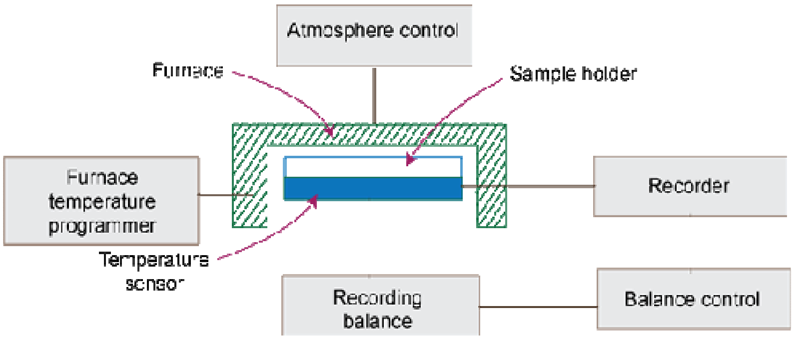

Figure 5: Block Diagram of a Thermobalance.

3.2 Differential Scanning Calorimetry (DSC)

The DSC is generic term for the following two measurement methods.

3.2.1 Heat Flux DSCs

Specified program is varied, where it can be used a technique in which the temperature of the sample unit, formed by a sample and reference material, the function of temperature is measured by the temperature difference between the sample and the reference material.

3.2.2 Power Compensation DSC

A function of the temperature is to equalize their temperature is a technique in which difference of thermal energy that is applied to the sample and reference material per unit of time is measured, the sample and reference material is formed by the temperature of the sample unit and specified program is varied. Block diagram of Heat Flux DSC is as given in Figure 6.

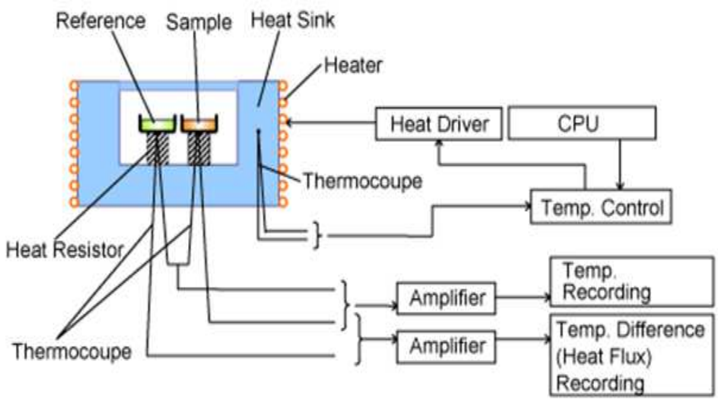

Figure 6: Block Diagram Heat Flux DSC.

3.3 Fourier Transform Infrared Spectroscopy (FTIR)

FTIR is mostly used for finding the chemicals whether they are organic or inorganic. An unknown mixture of some components can be utilized to quantitative and for the analysis of three states such as solids, liquids and gaseous. To develop the term FTIR in the manner where we have to collect the data and converted from a spectrum to interference pattern. In FTIR, identifying types of chemical bonds is a powerful tool, using that it can be find molecule by producing an infrared absorption spectrum that is like a molecular “finger print”. The characteristics of the chemical bond having the wave length of light absorbed can be seen in this annotated spectrum.

3.3.1 Basic Principle

Depending on the elements and the types of bonds, there are various frequencies which vibrate molecular bonds. There are several specific frequencies, for any given bond at which it can vibrate. According to the corresponding ground state, these frequencies have a quantum mechanics and several excited states. Exciting the bond through absorbing light energy there is one way to cause the frequency of a molecular vibration has to increase. For any given transition between two states, the light energy (determined by wave length) must exactly equal the difference in the energy between the ground state and the first excited state.

Unique Features

Permanently aligned have a high sensitivity performance, high cube corner interferometer, perfectly adjustable work spaces, hyper spectral imagining, thermo gravy metric coupling, easy measurement mode and high through put screening devices. The block diagram of the FT-IR is as given in Figure 7.

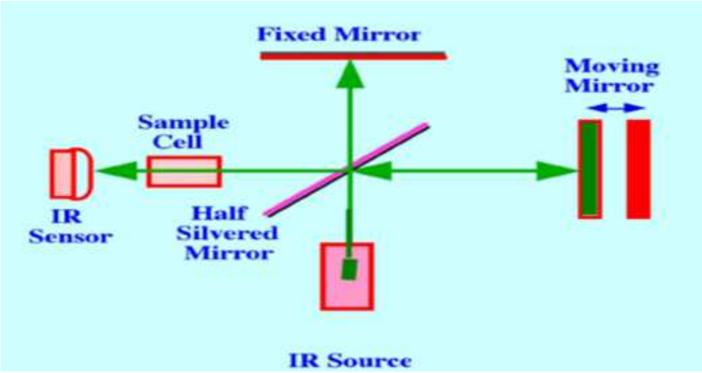

Figure 7: Block Diagram of FTIR.

The schematic diagram of the FTIR is as given in figure 8

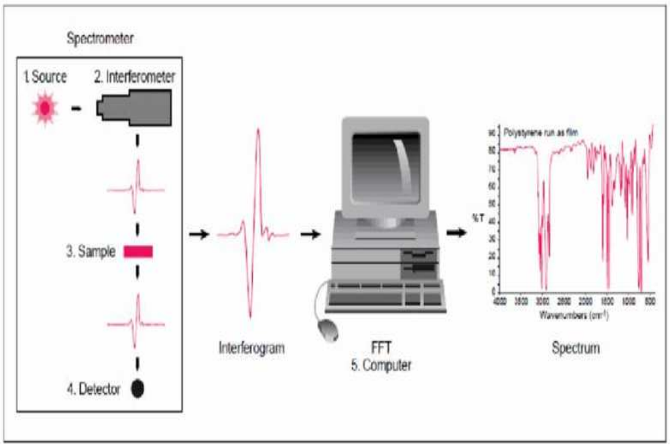

Figure 8: Schematic Diagram of FTIR Spectrometer.

3.4 Metal Flow Index (MFI)

Melt Flow Index is defined as the measure of the easy of melt flow of thermo plastic material in gram, over the course of ten minutes at a certain standard. Temperature is 230 degree centigrade. Flow ability of thermo plastic is determined by the melt flow index. The equipment called melt flow tester is used to check the melting property of thermo plastic material.

3.4.1 Procedure to Determine MFI

Measured amount of the polymer grains samples is taken to calculate the MFI with the waiting machine; generally ten grams of polymer samples are more enough to test the MFI. The testing machine set up has to rise the temperature from 0 to 230 degree centigrade before conducting the experiment of MFI testing. The sample is poured in to the set up through scoop and then waits till it reaches to the above temperature, standard weight is placed on the MFI after reaching the desired temperature, then note down the time when the material starts coming out of the machine. From the setup, collect the each sample weight and time of the stroke for the sample when it comes from the MFI tester machine. The block diagram of MFI equipment is as given in Figure 9.

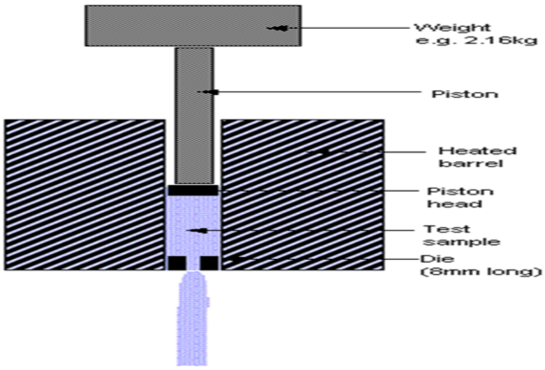

Figure 9: Block Diagram of MFI.

The schematic diagram of MFI equipment is as given in figure 10

Figure 10: Schematic Diagram of MFI.

3.5 Specific Gravity

Specific Gravity (SG) - is defined as the ratio of the density of a substance to the density of water - at a specified temperature and can be expressed as

$$SG = \rho_{substance} / \rho_{H2o}$$

It is common to use the density of water at 4°C (39°F) as a reference since water at this point has its highest density of 1000 kg/m3 or 1.940 slugs/ft3.

It is dimensionless; it has the same value in the SI system. SG of a fluid will have same numerical value as its density given in g/mL or Mg/m3. Water is also used as reference when identifying the specific gravity for solids. Schematic diagram of specific gravity equipment is as given in Figure 11.

Figure 11: Schematic Diagram of SG Equipment.

4. RESULTS

The TGA test results with different ratios are as given in figure 12 to figure 18

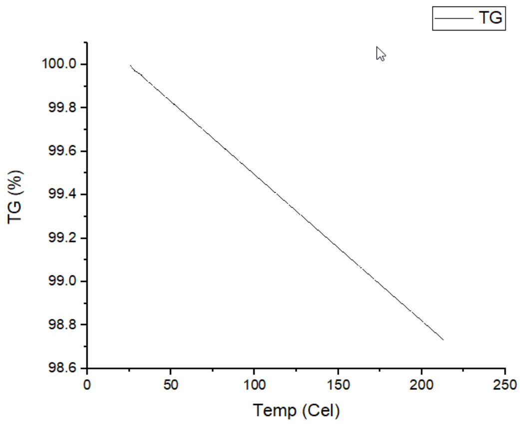

Figure 12: Thermo Gravimetric Analysis with Ratio 80H-10CF-10SD.

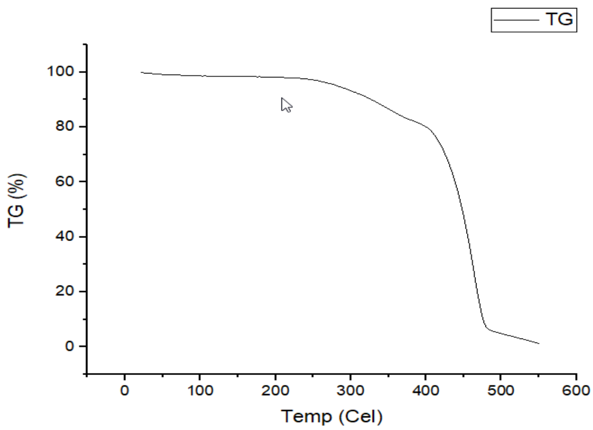

Figure 13: Thermo Gravimetric Analysis with Ratio 80H-5CF-15SD.

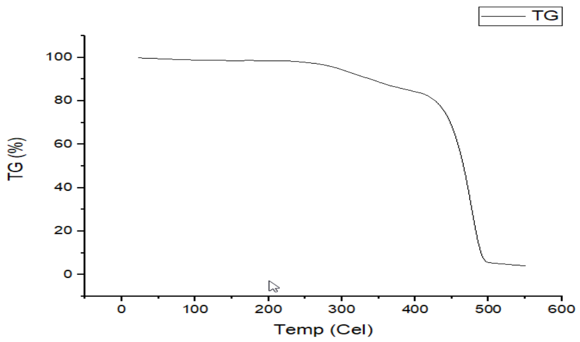

Figure 14: Thermo Gravimetric Analysis with Ratio 80H-15CF-5SD.

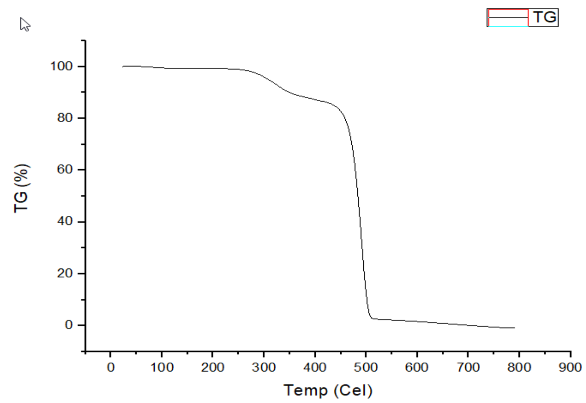

Figure 15: Thermo Gravimetric Analysis with Ratio 80H:20CF.

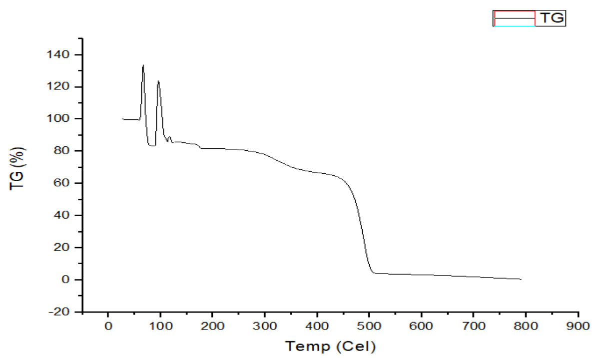

Figure 16: Thermo Gravimetric Analysis with Ratio 70H:30CF.

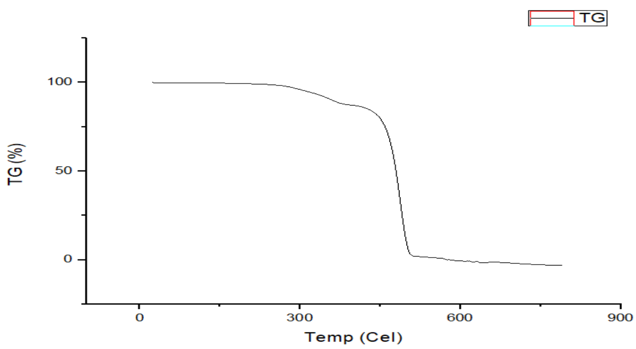

Figure 17: Thermo Gravimetric Analysis with Ratio 70H: 30SD.

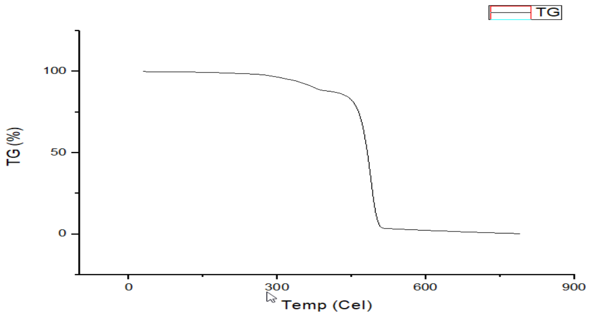

Figure 17: Thermo Gravimetric Analysis with Ratio 80H: 20SD.

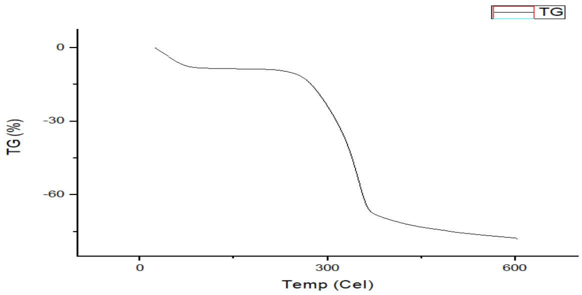

Figure 18: Thermo Gravimetric Analysis with Ratio Saw Dust.

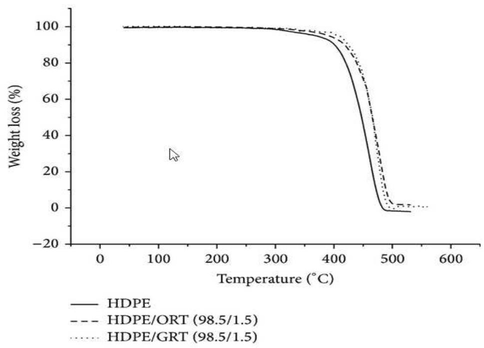

Figure 18: Thermo Gravimetric Analysis with Ratio HDPE Granules.

The DSC results of composition with various ratios are as given in figure 19 and figure 28

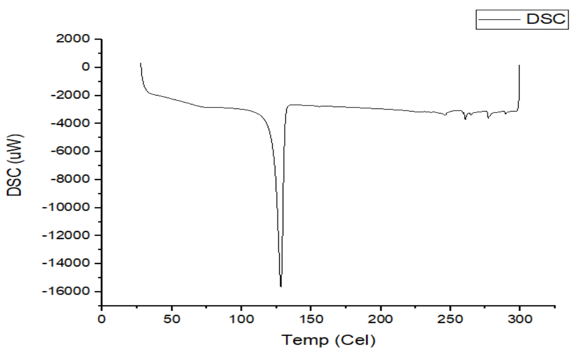

Figure 19: Differential Scanning Calorimetry Test Results with 80H-10CF-10SD.

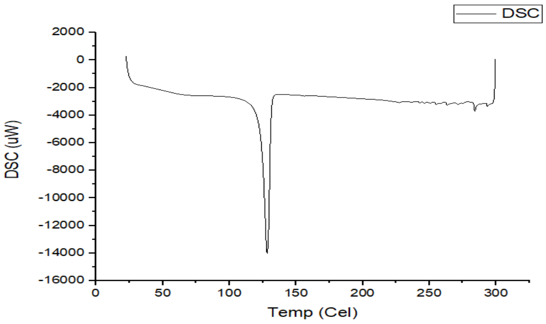

Figure 20: Differential Scanning Calorimetry Test Results with 80H-5CF-15SD

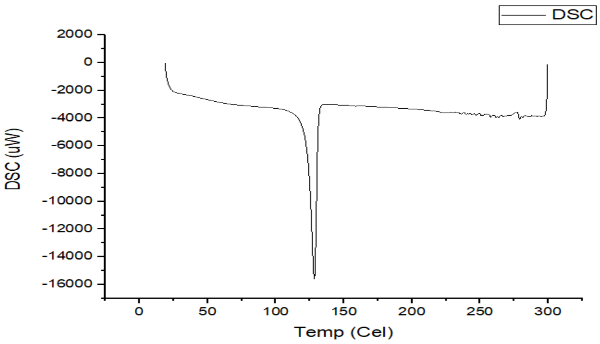

Figure 21: Differential Scanning Calorimetry Test Results with 80H-5CF-15SD.

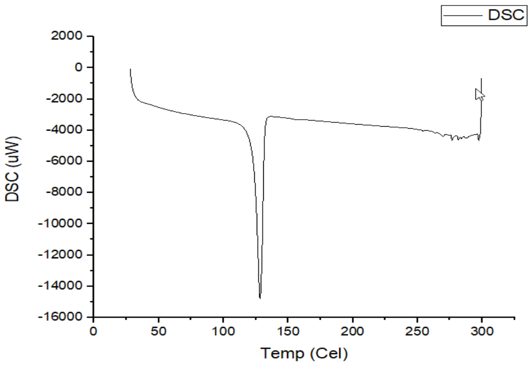

Figure 22: Differential Scanning Calorimetry Test Results with 80H: 20CF.

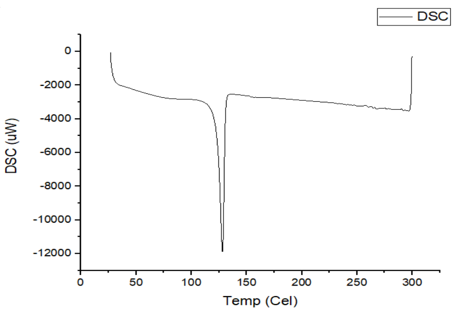

Figure 23: Differential Scanning Calorimetry Test Results with 70H: 30CF.

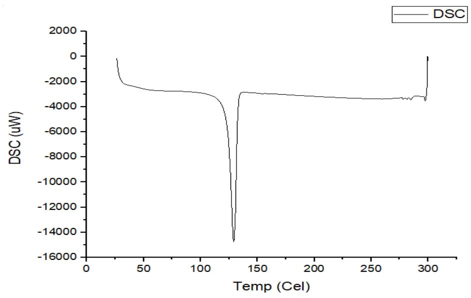

Figure 24: Differential Scanning Calorimetry Test Results with 70H: 30SD.

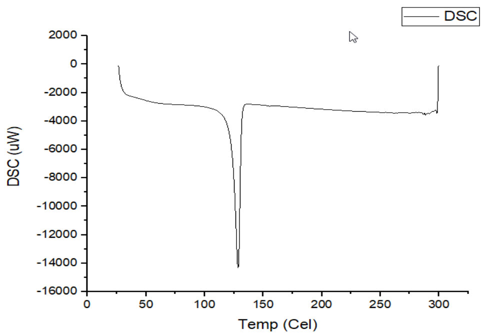

Figure 25: Differential Scanning Calorimetry Test Results with 80H: 20SD.

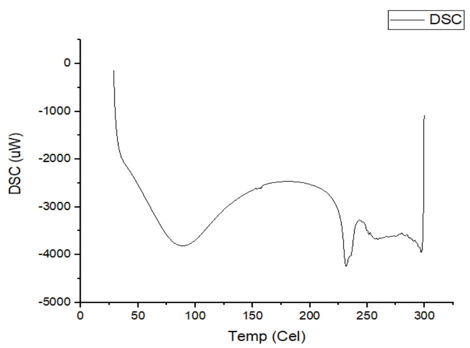

Figure 26: Differential Scanning Calorimetry Test Results with RACHIS.

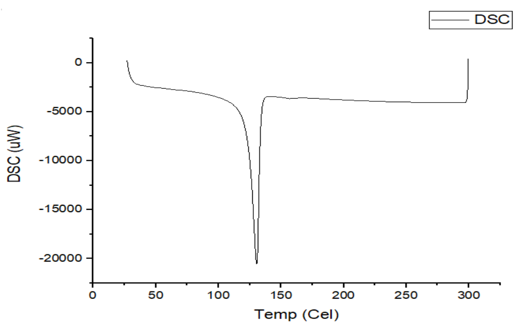

Figure 27: Differential Scanning Calorimetry Test Results with SAW DUST.

4.1 FTIR Results

The Fourier Transform Infrared Spectroscopy test results are as given in figure 29 and figure 37.

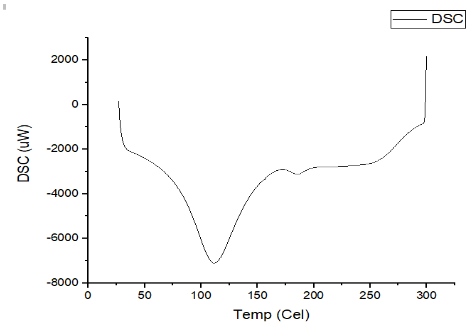

Figure 28: Differential Scanning Calorimetry Test Results with HDPE GRANULES.

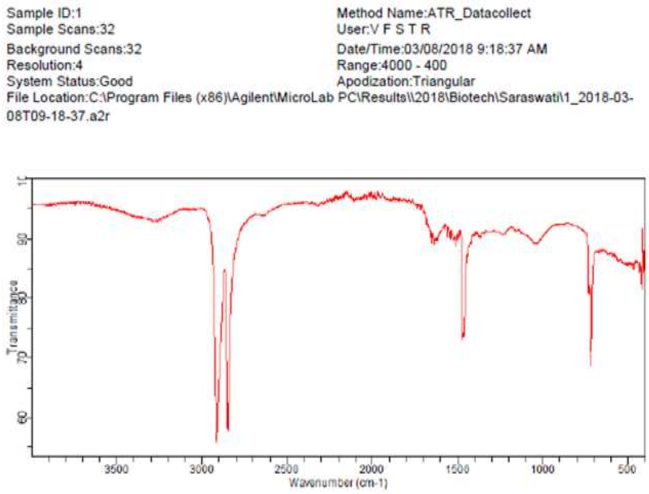

Figure 29: Fourier Transform Infrared Spectroscopy Test Results with Ratios 80H-10CF-10.

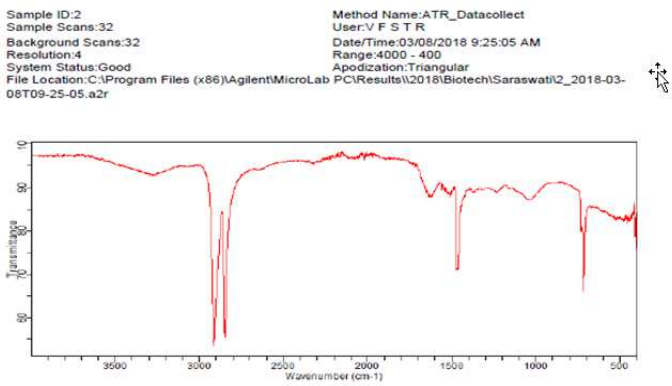

Figure 30: Fourier Transform Infrared Spectroscopy Test Results with Ratios 80H-5CF-15SD.

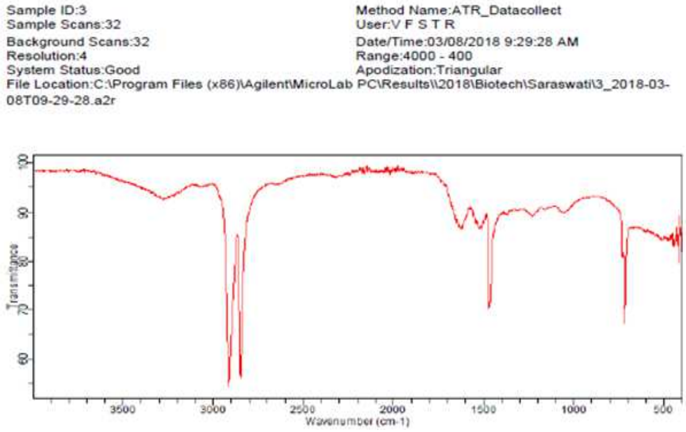

Figure 31: Fourier Transform Infrared Spectroscopy Test Results with Ratios 80H-15CF-5SD.

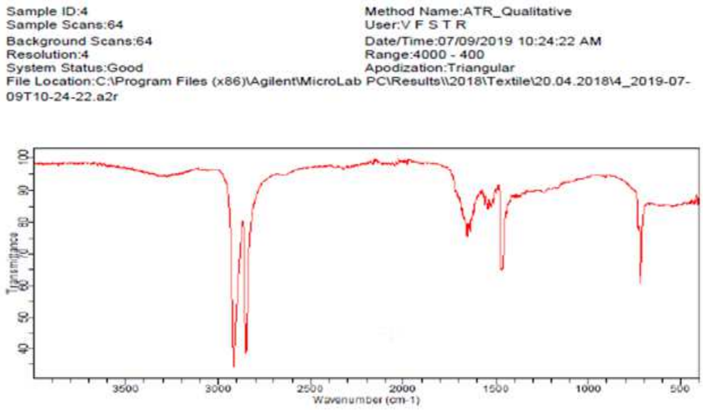

Figure 32: Fourier Transform Infrared Spectroscopy Test Results with Ratios 80H:20CF.

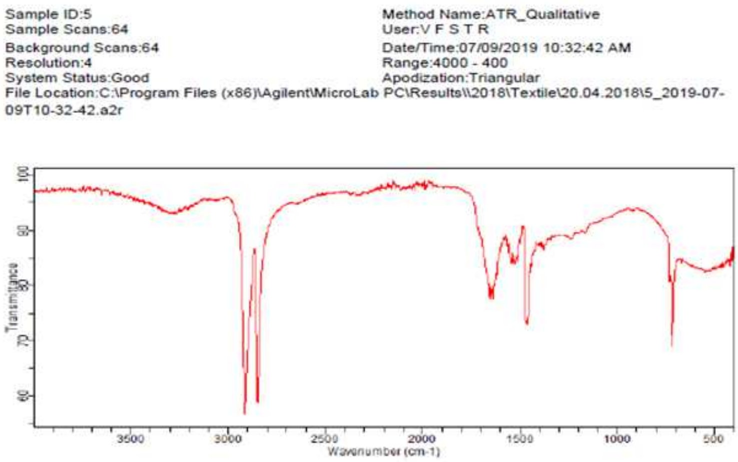

Figure 33: Fourier Transform Infrared Spectroscopy Test Results with Ratios 70H:30CF.

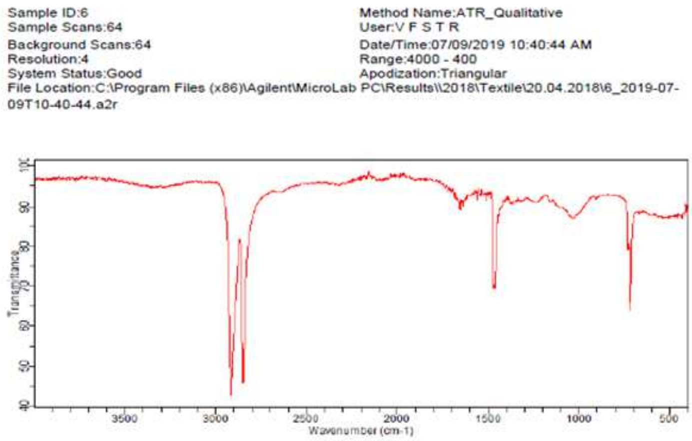

Figure 34: Fourier Transform Infrared Spectroscopy test results with ratios 70H:30SD.

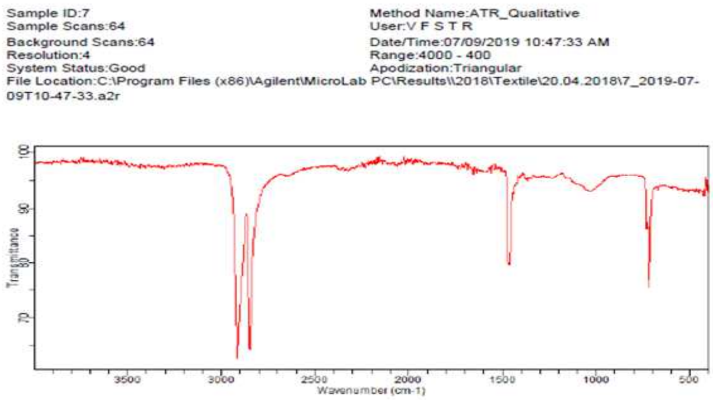

Figure 35: Fourier Transform Infrared Spectroscopy Test Results with Ratios 80H:20SD

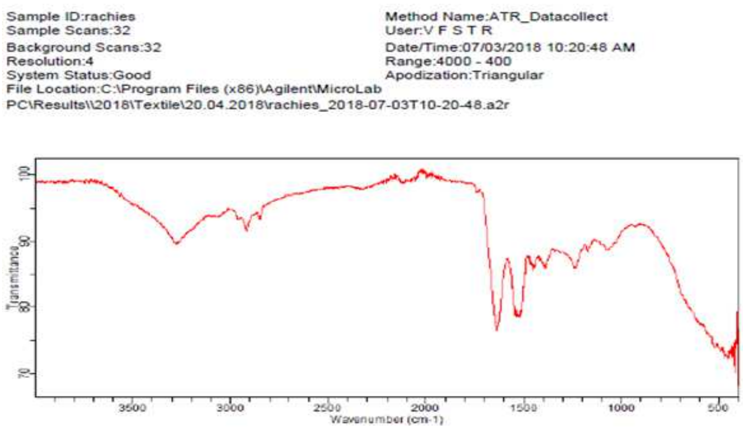

Figure 36: Fourier Transform Infrared Spectroscopy Test Results with Ratios RACHIS

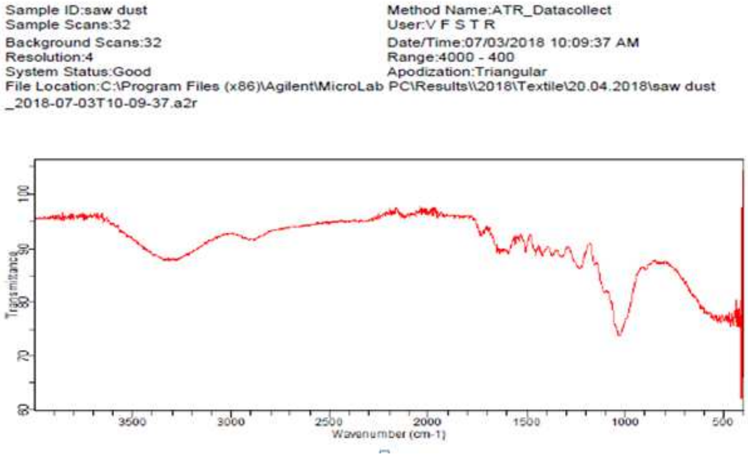

Figure 37: Fourier Transform Infrared Spectroscopy Test Results with Ratios SAW DUST.

Table 1: MFI Test Results

Sl. No	Sample	MFR	Load kg	Temp °C	Total Samples Collected	Sample Time(sec)	Sample Weight
1	80H-10CF-10SD	0.2340	2.60	160	10	1.04	0.078
2	80H-5CF-15SD	000.86	2.16	160	10	1.04	0.038
3	80H-15CF-5SD	000.90	2.16	160	10	1.04	0.031
4	80H:20CF	0.25650	2.60	160	10	1.04	0.855
5	70H:30CF	000.125	2.16	160	10	1.04	0.40
6	70H:30SD	0.41040	2.50	160	10	1.04	0.36
7	80H:20SD	000.364	2.50	160	10	1.04	0.69

Table 2: Specific Gravity Results

Sl. No	Sample	S. G
1	80H-10CF-10SD	2.1111
2	80H-5CF-15SD	1.0340
3	80H-15CF-5SD	1.1313
4	80H:20CF	1.0227
5	70H:30CF	1.0366
6	70H:30SD	1.1466
7	80H:20SD	1.1395

5. CONCLUSIONS

The three materials, out of which, two are fibres and the other is matrix such as Chicken Feather fiber, Neem Saw dust and HDPE granules combined are reinforced hybrid material. These three materials are compounded in different ratios such as80H-10CF-10SD, 80H-5CF-15SD,80H-15CF-5SD,80H:20CF, 70H:30CF,70H:30SD, 80H:20SD. TGA tests are performed on all the ratios, and it was observed that mass of the material is decreasing in a better way with respect to temperature in 80H-10CF-10SD ratio mixing. DSC tests also shows that the 80H-10CF-10SD ratio mixing will have better temperature properties compared to remaining ratios. MFI and specific gravity tests also performed to ensure the mechanical properties of all ratios. The 80H-10CF-10SD ratio is having 0.2340, which is highest of all with a 0.078 sample weight. The specific gravity of 80H-10CF-10SD ratio is 2.1111, which is highest of all ratios. The reinforced material is having highest mechanical and thermal properties.

REFERENCES

1. *Najafi SK (2013) Use of recycled plastics in wood plastic composites– a review. Waste Manage 33:1898–1905*
2. *Nadir ayrilmis, "Combined effects of boron and compatibilizer on dimensional stability and mechanical properties of wood/HDPE composites", vol 44, 2013, pgs 745-749.*
3. *Maija pollanen,"Cellulose reinforced high density polythene composites-morphology, mechanical and thermal expansion properties", vol 76,2013, pgs 21-28*
4. *U. Gayatri, G. Srinivasarao, M. Ramakrishna," Development and characterization of chicken feather rachis, sawdust and HDPE hybrid composite material " Issue.4, Vol.28, pp.509-528, December 2018.*
5. *Emarah, A. M., Metwally, K. G., & Zaghw, A. I. Comparative Analytical Study Of Reinforced Concrete Wall Subjected To Blast Loading Pattern.*
6. *Supri A. Ghani, Soo Jin Tan, Teh Soo Yeng," Properties of Chicken Feather Fiber-Filled Low-Density Polyethylene Composites: The Effect of Polyethylene Grafted Maleic Anhydride" Vol.52, pp.495–500, October 2014.*
7. *Isiaka Oluwole Oladele, Avwerosuoghene Moses Okoro, Joseph Ajibade, Omotoyinbo & Moshibudi Caroline Khoathane," Evaluation of the mechanical properties of chemically modified chicken feather fibres reinforced high density polyethylene composites" Journal of Taibah University for Science, Issue-1, Vol.12,2018, pp.1-8.*
8. *Mutar, M. A., & Attab, Z. H. A. Synthesis, Characterization, And Properties of New Unsaturated Polyesters Resins Reinforced With Some Fillers (Carbon Nano, Nano Tio2, Tio2 And Zno) For Composite Application.*
9. *Abdul Ghani Supri, A Emy Aizat, MIM Yazid, M Masturina" Chicken feather fibers–recycled high-density polyethylene composites: The effect of ε-caprolactam" Journal of Thermoplastic Composite Materials, 2015, Vol. 28(3) 327–339.*
10. *Masoudreza Habibi1, Saeed Kazemi Najafi, Ismail Ghasemi" Rheological and mechanical properties of composites made from wood flour and recycled LDPE/HDPE blend" Iran Polym J, December 2017, Volume 26, Issue 12, pp 949–956.*
11. *Moballegh L, Hakim S, Morshedian J, Schausberger A (2017) Rheological characterization of polypropylene/poly(ethylene-copropylene) in-reactor blends synthesized under different polymerization conditions. Polym Bull 74:1045–1060*
12. *Peddi, S. P., & Sadeh, B. A. Modified Urea Route (Mur) Synthesis Of Nd 3: Y2o3 Nanoparticles Suitable For Industrial Production.*
13. *Ares A, Bouza R, Pardo SG, Abad MJ, Barral L (2010) Rheological, mechanical and thermal behaviour of wood polymer composites based on recycled polypropylene. J Polym Environ 18:318–325*
14. *Moballegh L, Hakim S, Morshedian J, Schausberger A (2017) Rheological characterization of polypropylene/poly(ethylene-copropylene) in-reactor blends synthesized under different polymerization conditions. Polym Bull 74:1045–1060*
15. *Hameed T, Hussein IA (2004) Effect of short chain branching of LDPE on its miscibility with linear HDPE. Macromol Mater Eng 289:198–203*
16. *Huda, S.; Yang, Y. Feather fiber reinforced light weight composites with good acoustic properties. J. Polym. Environ. 2009, 17, 131–142.*

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